Response to the comments of Dwivedi and Srivastava on the propagation and dissipation of Alfvén waves in coronal holes

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Abstract: Chandra [1] made an attempt to show that the work of Dwivedi and Srivastava [2] (hereinafter DS) can be investigated even analytically and their results are erroneous. Dwivedi and Srivastava [3] picked up some values of Chandra [1] and tried to show that they are not physically acceptable. Some results of Chandra [1] are not physically acceptable, as these are the outcome of the wrong approach of DS. However, the results are numerically correct whereas the results of DS are numerically wrong.

1   Introduction

In order to show that the work of Dwivedi and Srivastava [2] (hereinafter DS) can be investigated even analytically, Chandra [1] used the condition $\omega\nu >> v_A^2$ for the case of $\eta = 0$ and $\omega\eta << v_A^2$ for the case of $\nu = 0$. His also proved that the results of DS are wrong. Dwivedi and Srivastava [3] should not misguide the scientific community by wrongly interpreting these conditions, as the numerical calculations can also prove that the results of DS are wrong. Moreover, as a consequence of the wrong approach of DS, some numerical results obtained by Chandra [1] are not physically acceptable. In the present work we have shown numerically that the results of DS are wrong.

2   Formulation

The dispersion relation derived by Pekünlü et al. [4] for the MHD equations can be expressed as [1, 2, 4]

$$\nu\eta k^4 + [v_A^2 - i\omega(\nu + \eta)]k^2 - \omega^2 = 0 \tag{1}$$

Consideration of an atmosphere with (i) $\nu = 0$ (no viscosity) or (ii) with $\eta = 0$ (no magnetic diffusivity) may not be a physically acceptable situation. However, DS discussed these two cases numerically, where they got wrong results. Let us now investigate these two cases numerically. For either of the cases, the first term $\nu\eta k^4$ is zero and we have

$$\left[v_A^2 - i\omega(\nu + \eta)\right]k^2 - \omega^2 = 0 \tag{2}$$

It is matter of surprise that Dwivedi and Srivastava [3] are asking for solving equation (refeq0) numerically. For real values of ω, the wave number k can be assumed to

have complex values. For $k = k_r + ik_i$, we can derive the values of k_r and k_i for the said two cases as the following:

(i) There is viscosity only . That is, there is no magnetic diffusivity ($\eta = 0$). For this case, equation (2) gives [1, 2]

$$k_r^4 - P\, k_r^2 - Q^2 = 0 \qquad \text{and} \qquad k_r k_i = Q \qquad (3)$$

where

$$P = \frac{\omega^2 v_A^2}{v_A^4 + \omega^2 \nu^2} \qquad \text{and} \qquad Q = \frac{\omega^3 \nu}{2(v_A^4 + \omega^2 \nu^2)}$$

Form equation (3), we get

$$k_r^2 = \frac{\omega^2 v_A^2}{2(v_A^4 + \omega^2 \nu^2)} \left[1 + \sqrt{1 + (\omega \nu / v_A^2)^2}\right] \qquad (4)$$

(ii) There is magnetic diffusivity only. That is, there is no viscosity ($\nu = 0$). For this case, equation (2) gives [1, 2]

$$k_r^4 - P' k_r^2 - Q'^2 = 0 \qquad \text{and} \qquad k_r k_i = Q' \qquad (5)$$

where

$$P' = \frac{\omega^2 v_A^2}{v_A^4 + \omega^2 \eta^2} \qquad \text{and} \qquad Q' = \frac{\omega^3 \eta}{2(v_A^4 + \omega^2 \eta^2)}$$

Form equation (5), we get

$$k_r^2 = \frac{\omega^2\, v_A^2}{2(v_A^4 + \omega^2 \eta^2)} \left[1 + \sqrt{1 + (\omega \eta / v_A^2)^2}\right] \qquad (6)$$

3   Results

In order to get numerical values for k_r and k_i, for the two cases, we require values of physical parameters. The values of physical parameters are provided by Chandra [1] and some of them are given in Table 1. In order to find out the source of error in the work of DS, we asked them several times to provide us the values of physical parameters used in their work, but they never showed the courtesy to reply. For $\tau = 10^{-4}$ s, the calculations are made and the results are given in Table 1. The damping length scale D and the wavelength λ of the wave are

$$D = \frac{2\pi}{k_i} \qquad \text{and} \qquad \lambda = \frac{2\pi}{k_r}$$

The results for the case $\eta = 0$ show that the damping length scale and the wavelength are of the same magnitude, which is of the order of 10^4 m. For the case $\nu = 0$, the damping length scale comes out of the order of 10^{11} m.This physically unacceptable result is obviously a consequence of the wrong approach of DS. Comparison of the present results with those of DS show that their results are wrong. Even the nature of the variation of D is quite different.

Table 1: Values of k_r and k_i for the two cases.

R^a	ν^b	η^c	v_A^d	$\nu = 0$		$\eta = 0$	
				k_r	k_i	k_r	k_i
1.05	0.20	3.79	3.25	1.94E-02	2.19E-10	1.26E-03	1.25E-03
1.07	0.48	2.45	3.26	1.93E-02	1.40E-10	8.09E-04	8.06E-04
1.09	0.93	1.80	3.26	1.93E-02	1.03E-10	5.82E-04	5.81E-04
1.11	1.56	1.44	3.26	1.93E-02	8.23E-11	4.48E-04	4.48E-04
1.13	2.40	1.21	3.24	1.94E-02	7.01E-11	3.62E-04	3.62E-04
1.15	3.44	1.06	3.23	1.95E-02	6.24E-11	3.02E-04	3.02E-04
1.17	4.65	0.96	3.21	1.96E-02	5.77E-11	2.60E-04	2.60E-04
1.19	6.01	0.89	3.18	1.97E-02	5.48E-11	2.29E-04	2.29E-04
1.21	7.46	0.85	3.16	1.99E-02	5.34E-11	2.05E-04	2.05E-04
1.23	8.92	0.83	3.13	2.00E-02	5.30E-11	1.88E-04	1.88E-04
1.25	10.31	0.82	3.11	2.02E-02	5.35E-11	1.75E-04	1.75E-04
1.27	11.50	0.83	3.10	2.03E-02	5.46E-11	1.65E-04	1.65E-04
1.29	12.40	0.85	3.10	2.03E-02	5.63E-11	1.59E-04	1.59E-04
1.31	12.88	0.89	3.11	2.02E-02	5.86E-11	1.56E-04	1.56E-04
1.33	12.86	0.96	3.14	2.00E-02	6.12E-11	1.56E-04	1.56E-04
1.35	12.26	1.06	3.20	1.97E-02	6.43E-11	1.60E-04	1.60E-04

[a] Distance from the center of sun in $R_\odot$

[b] Coefficient of viscosity in 10^{11} m^2 s^{-1};

[c] Magnetic diffusivity in m^2 s^{-1}

[d] Alfvén velocity in 10^6 m s^{-1}

Acknowledgments

References

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